

A large satellite with two long solar panel arrays is shown in orbit above the Earth's blue and white horizon.

→ 2nd SENTINEL-2 VALIDATION TEAM MEETING

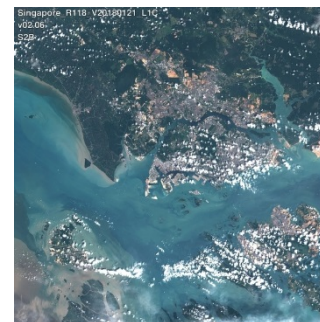
29–31 January 2018 | ESA–ESRIN | Frascati (Rome), Italy

ESA UNCLASSIFIED - For Official Use

Sen2Cor 2.5: Cloud Screening & Scene Classification Algorithm

ESA UNCLASSIFIED - For Official Use

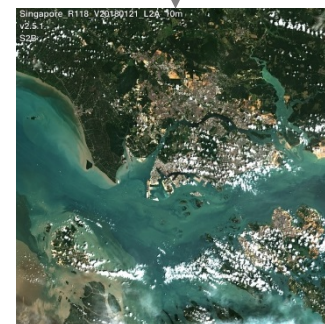
1. Sen2Cor Processor
2. Scene Classification overview
3. Cloud / Snow detection algorithm (...)
4. Known limitations of version 2.4
5. Version 2.5 with ESA CCI aux data
6. Recommendations / Discussion



TOA-RGB (L1C-input)

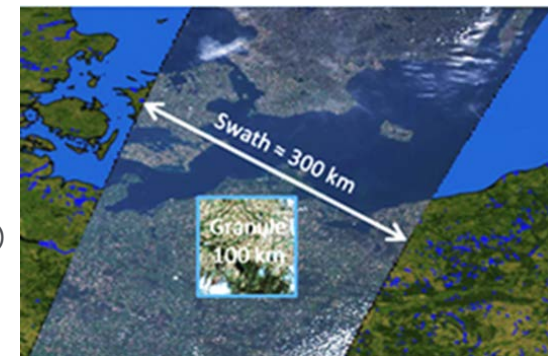
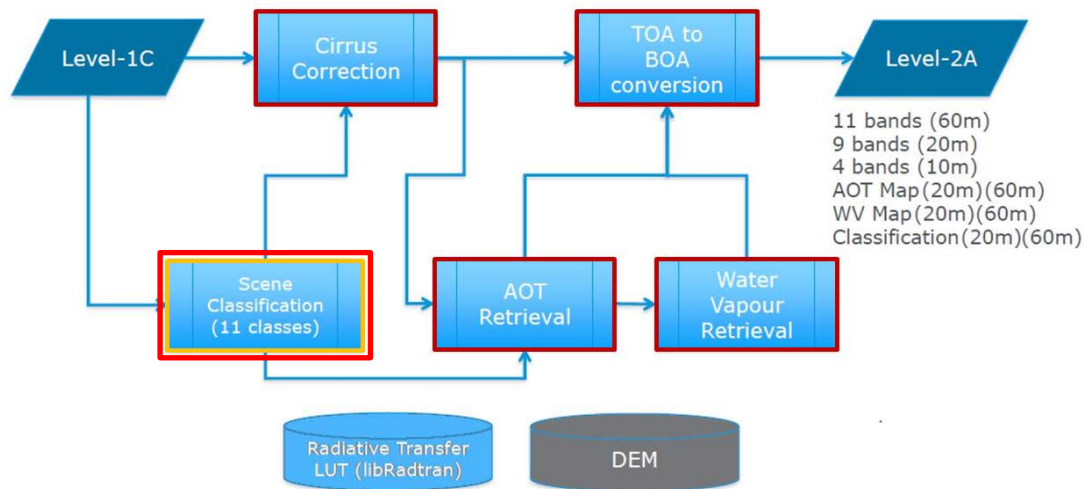


SCL (L2A-output)



BOA-RGB (L2A-output)

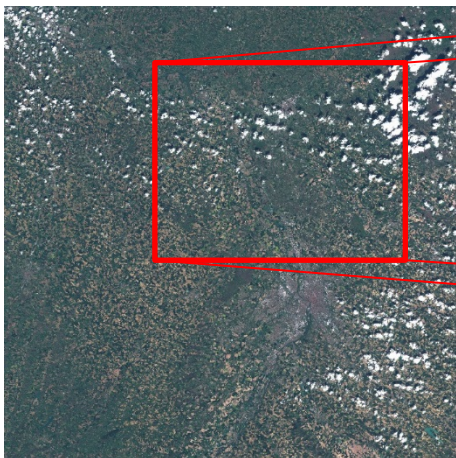
- Atmospheric correction processor for **Sentinel-2 data**
 - Single-Mission tool for Sentinel-2 mission
 - Atmospheric Correction over land surface
 - Processing mono-temporal orthorectified L1C granules
 - Two main modules : **Scene Classification (SCL)** and Atm. Correction (AC)



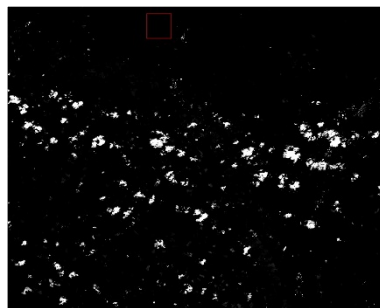
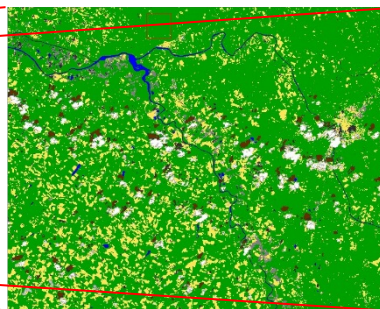
- **SCL: series of threshold tests on L1C spectral bands, band ratios and indices**
- AOT (550 nm): DDV-algorithm
- Optional cirrus correction preprocessing
- WV retrieval: Atmospheric Pre-corrected Differential Absorption Algorithm (APDA)
- BOA: terrain correction, adjacency corr., empirical Bidirectional Reflectance Distribution Function (BRDF) corrections

Cloud Screening and Scene Classification outputs

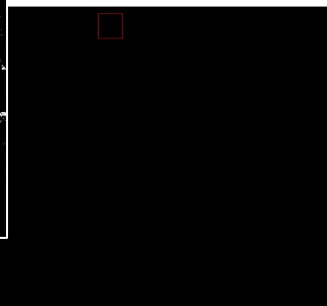
L1C Tile 31TCJ



Scene Classification



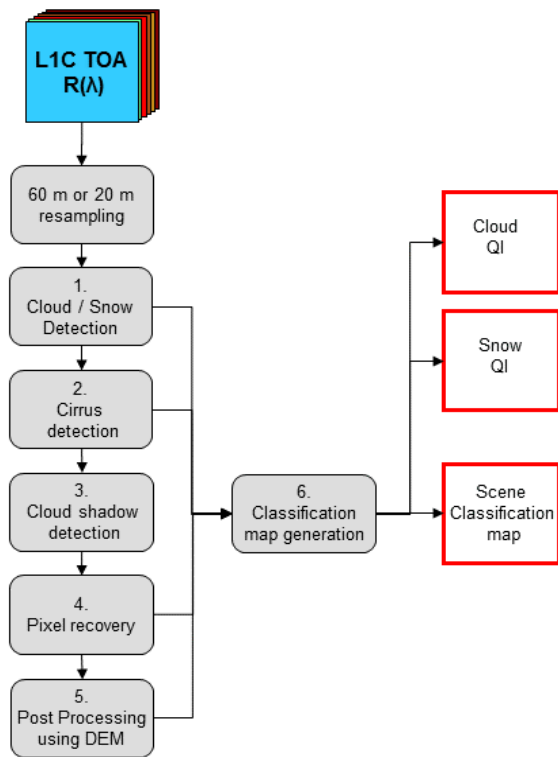
Cloud Confidence QI



Snow
Confidence QI

Label	Classification
0	NO_DATA
1	SATURATED_OR_DEFECTIVE
2	DARK_AREA_PIXELS
3	CLOUD_SHADOWS
4	VEGETATION
5	NOT_VEGETATED
6	WATER
7	UNCLASSIFIED
8	CLOUD_MEDIUM_PROBABILITY
9	CLOUD_HIGH_PROBABILITY
10	THIN_CIRRUS
11	SNOW

Cloud Screening and Classification overview



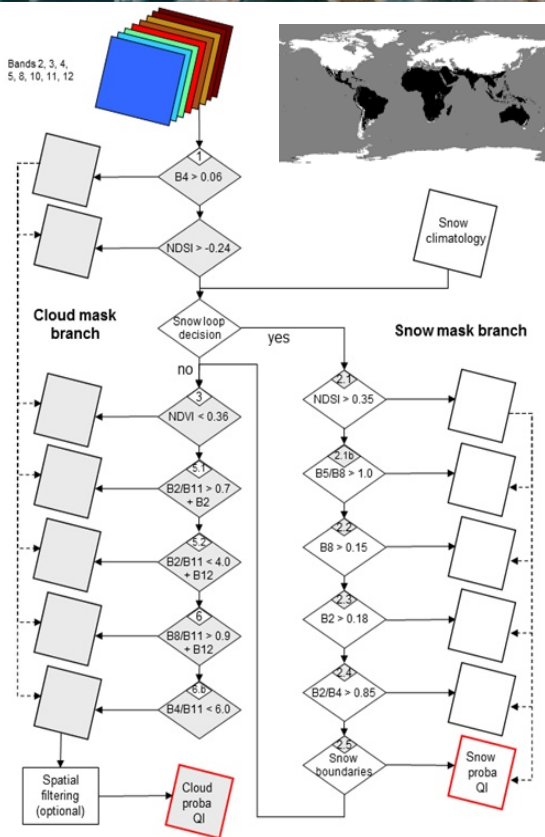
Several band ratios are used in this algorithm:

-> Importance of geolocation accuracy between spectral bands of different native resolutions

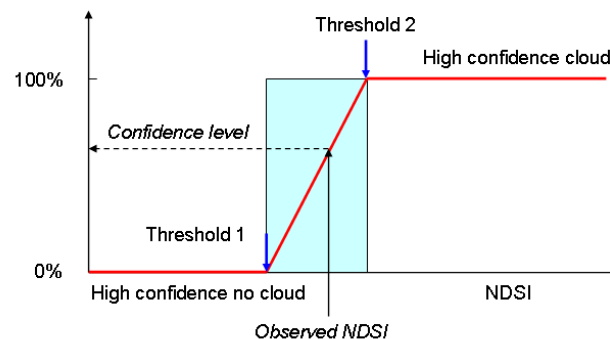
➤ For the **downsampling** (e.g. 10 m to 20 m) a block_reduce algorithm is used.

➤ For the **upsampling** (60 m to 20 m) a cubic spline is used.

Cloud and Snow detection algorithm



Sequence of filtering based on spectral bands thresholds, ratios and indexes computations (NDSI, NDVI)



The final cloud probability of a pixel is the product of all the individual tests.

Cirrus detection algorithm

- Cirrus cloud detection relies on **Sentinel-2 band 10 (1.375 μm)** reflectance thresholds.
- In a first step, pixels with a B10 reflectance value within a given range are classified as thin cirrus.
- In a second step, these pixels are confirmed as **thin cirrus** if their cloud probability < 20%
- Cirrus detection disabled if DEM > 1500 m to avoid false cirrus detection instead of snow / bright surface detection.



band 10



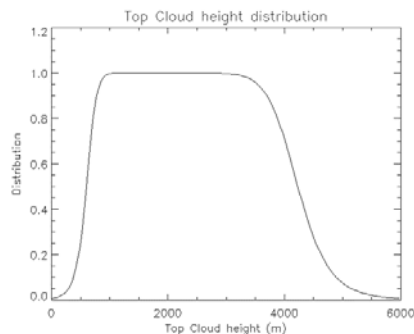
Cloud Shadow detection

Original image

Radiometric branch

Geometric branch

Final Cloud mask



Radiometric approach:

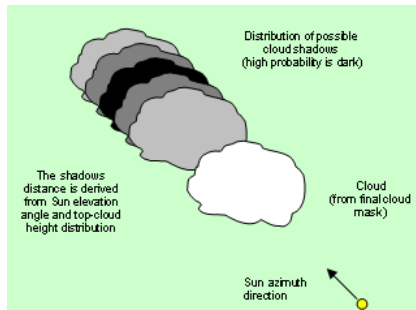
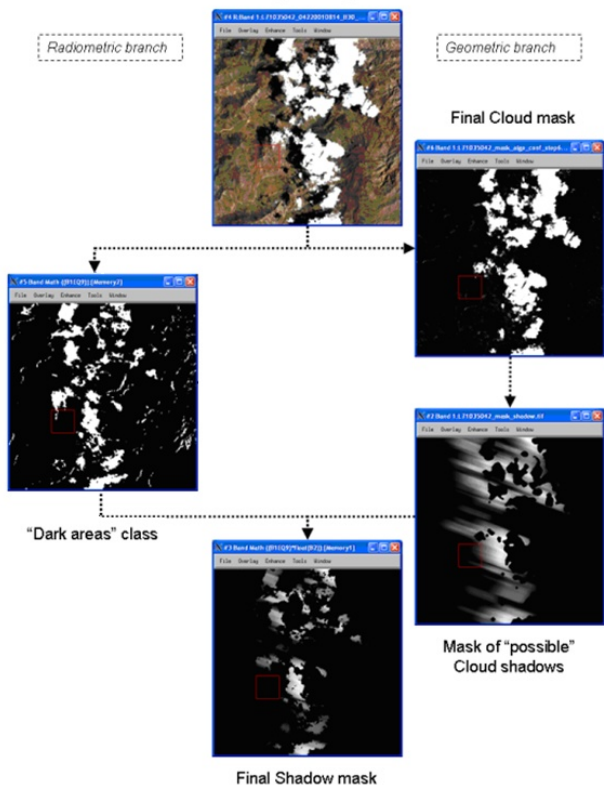
Dark areas and potential cloud shadows identified by their spectral signature using S2 spectral bands B2, B3, B4, B8, B11, B12.

Geometric approach:

Mask of probable cloud shadows derived using the final cloud mask, sun position and an a-priori distribution of top-cloud height.

Final step:

Final cloud shadow mask (probabilistic) obtained by multiplying the result of the radiometric branch by the result of the geometric branch.



Pixel recovery:

- After the cloud / snow / cloud shadow detection algorithm steps:

Check if pixels initially classified as “dark_features” pixels could be reclassified as vegetation or water pixels.

Post-Processing with DEM:

- This step consists in “cleaning” some pixels initially identified as “water”, “cloud shadow” or “cloud medium probability”, using the information provided by the Digital Elevation Model. Those pixels located in topographic shadows are then reclassified to “dark_features” pixels.

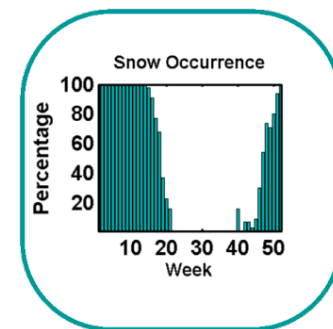
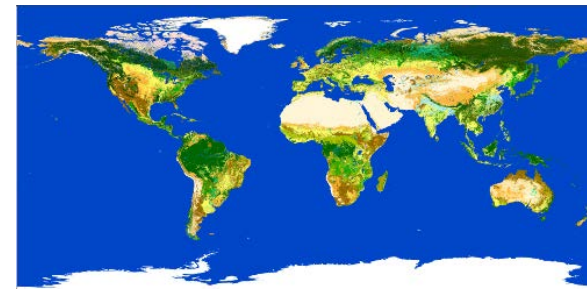
Known Limitations of Sen2Cor v2.4



- Over-detection of clouds when scene features spectral signature is very close to potential clouds like urban areas or bright areas (beaches of sand). This issue is now partially addressed in Sen2Cor 2.5 using the S2 bands sensitive to water vapour and the ESA CCI auxiliary information.
- Over-detection of snow in clouds. (e.g. shadows of vertical clouds over lower altitude clouds, potential ice clouds). This issue is now partially addressed in Sen2Cor 2.5 using the ESA CCI auxiliary information.
- Slight under-detection of “Thin” clouds over desert areas and water bodies.
- The topographic shadows are not differentiated from dark pixels.
- The cloud shadow detection over bright surfaces and the cirrus shadow detection.

Sen2Cor v.2.5 can use ESA CCI Maps a priori information (but not only)

- CCI-LC Water Bodies Map (5 years) at **150 m**
- Land Cover Map v.2.0.7 (2015) at **300 m**
 - urban class = 190
 - bare classes = 200, 201, 202
- CCI-LC Snow Condition (7-day) at **500 m**



<http://maps.elie.ucl.ac.be/CCI/viewer/download.php>

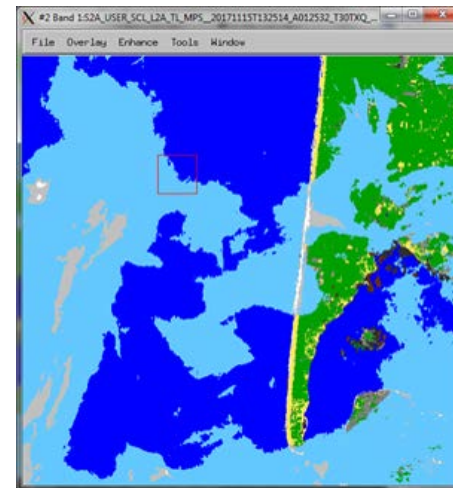
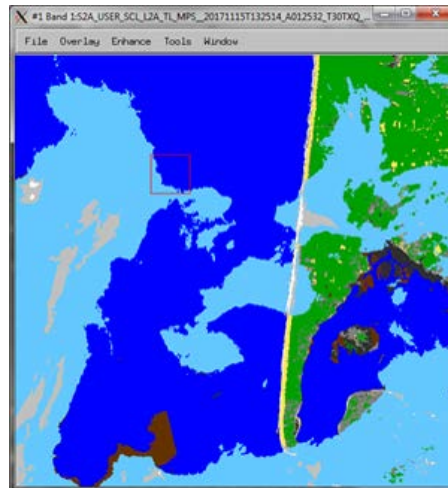
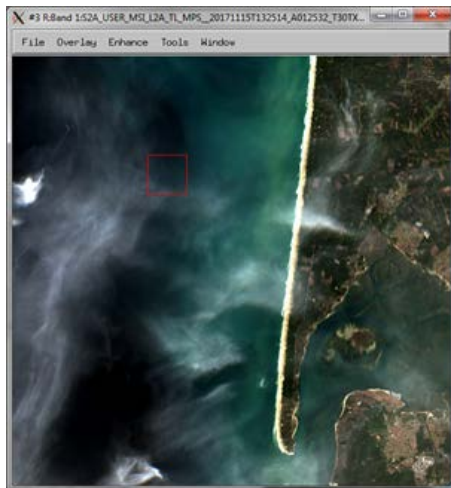
Sen2Cor v2.5 illustration: coastal / cirrus



L1C RGB

≤ 2.4

2.5



Tile: 30TXQ

Date: 20171115

Area: Arcachon, FR

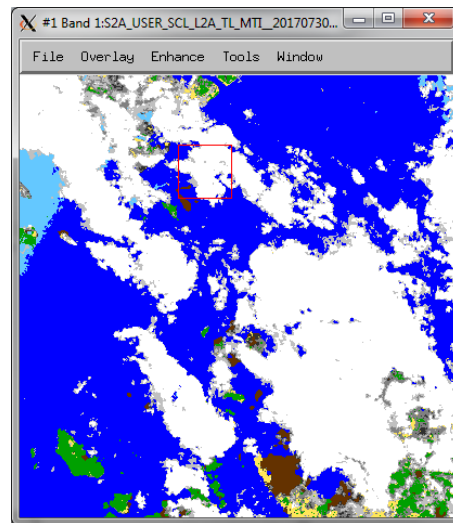
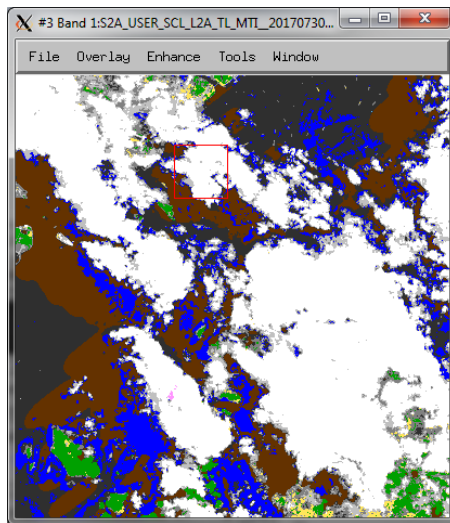
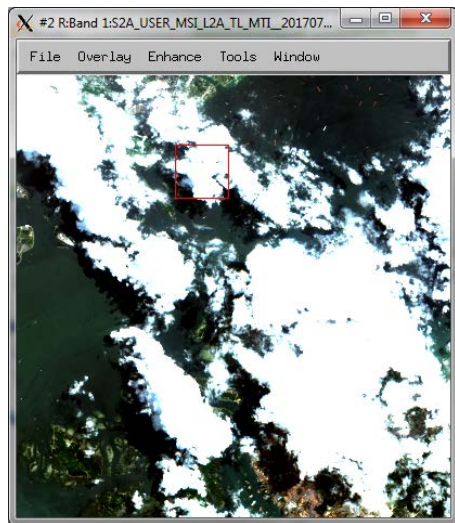
Sen2Cor v2.5 illustration: coastal / clouds / water



L1C RGB

≤ 2.4

2.5



Tile: 48NUG

Date: 20170730

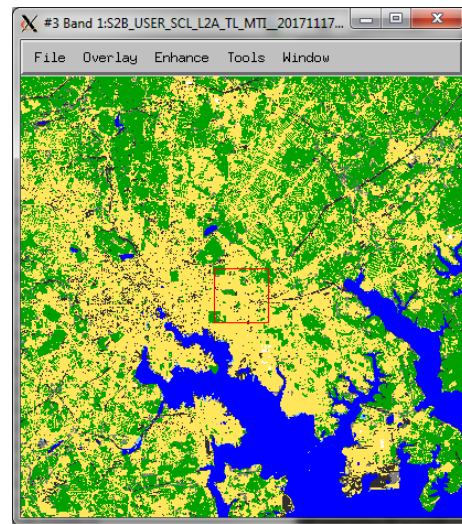
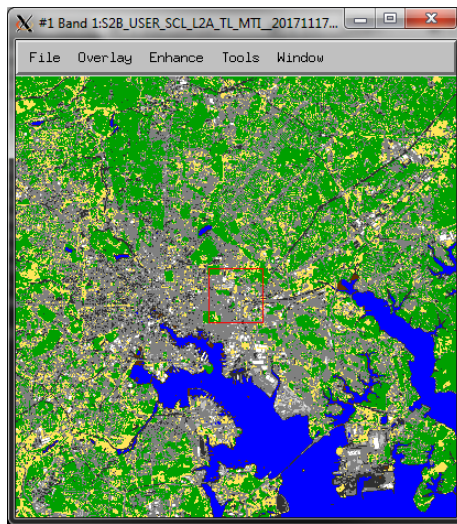
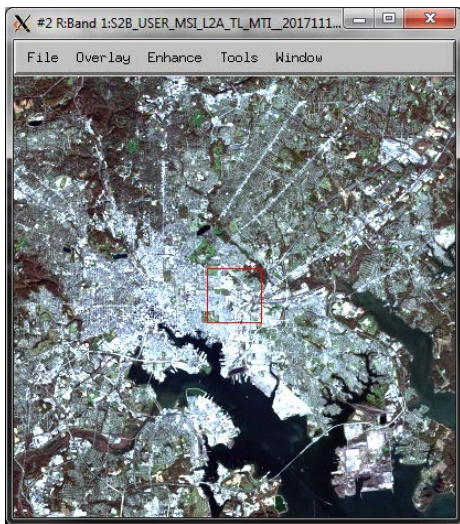
Area: Singapore

Sen2Cor v2.5 illustration: land / urban area

L1C RGB

≤ 2.4

2.5



Tile: 18SUJ

Date: 20171117

Area: Baltimore, US

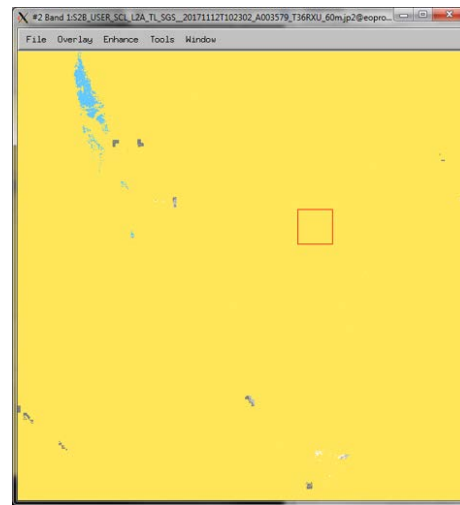
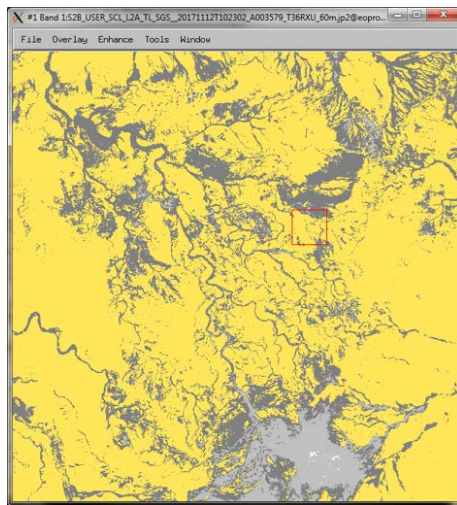
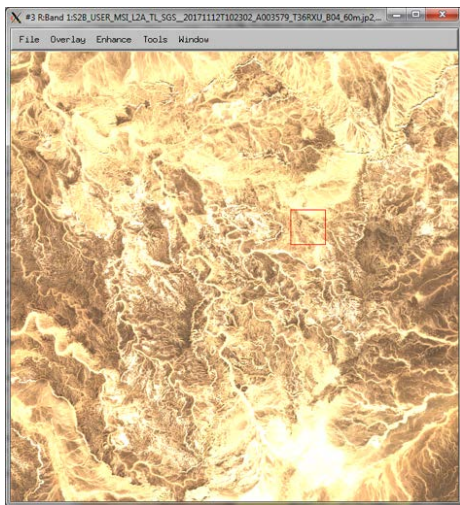
Sen2Cor v2.5 illustration: land / bright surface



L1C RGB

≤ 2.4

2.5



Tile: 36TXU

Date: 20171112

Area: Israël

- Set the usage of Digital Elevation Model (DEM) in Sen2Cor to ON.
- Starting with Sen2Cor v2.5, download and use ESA CCI auxiliary data.
- Sen2Cor L2A cloud mask is pixel based:

Depending on your application you may need to dilate Sen2Cor cloud mask to mask also the neighbouring cloud area?

-> This option is planned for future versions.

- L2A products version 2.5.2 (soon) available on OpenHub:

<https://scihub.copernicus.eu/dhus/>

- Sen2Cor version 2.5.2 for SNAP Toolbox (soon) available at:

<http://step.esa.int/main/third-party-plugins-2/sen2cor/>

Thank you for your attention !



Sen2Cor 2.5: Cloud Screening & Scene Classification Algorithm



Jérôme Louis
Vincent Debaecker

Jerome.louis@telespazio.com



Magdalena Main-Knorn
Bringfried Pflug



Uwe Müller-Wilm



Ferran Gascon



European Space Agency